M-TRAC

for rail safety

TECHNICAL ANALYSIS OF THE DANGERS TO THE PUBLIC IN THE TRANSPORT OF EMPTY HAZARDOUS GOODS TANK CARS

1983

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for rail safety

METRO TORONTO RESIDENTS' ACTION COMMITTEE

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S U B M I S S I O N

TO THE RAILWAY TRANSPORT COMMITTEE OF THE CANADIAN TRANSPORT COMMISSION

In the matter of the public inquiry into the railway accident at Winnipeg, Manitoba, on December 13, 1982.

We have invited one of the most eminent authorities in the field of chemical explosives to analyse and determine the dangers to the public in the event of a derailment or other railway accident involving hazardous goods cars classified as empty or less than one carload lot under the Show Cause Decision of 1981.

The document prepared by Professor D. H. Napier of the University of Toronto is attached and is submitted to the public inquiry under Subject No. 5 of Notice of Public Hearing dated January 31, 1983.

We respectfully submit that the dangers of the so-called "empty" hazardous goods tank cars can be so serious as to cause grave harm to the public in the event of a derailment or other railway accident.

We further remind the Commissioners that the Railway Transport Committee in the Show Cause Decision of 1981 determined that certain cities with heavy central populations face extreme difficulties in the evacuation of their people in the event of a chemical spill.

We therefore urgently plead with the Commissioners of this public inquiry to find that the dangers are of a kind that require the so-called "empty" hazardous goods cars to be included in the restraints imposed on certain hazardous goods cars under the Show Cause Decision of 1981.

February 16, 1983

Chairman
M-TRAC for rail safety

TO THE RAILWAY TRANSPORT COMMITTEE

OF THE CANADIAN TRANSPORT COMMISSION

In the matter of the public inquiry into the railway accident at Winnipeg, Manitoba, on December 13, 1982

ANALYSIS

DANGERS TO THE PUBLIC OF NON-PURGED HAZARDOUS GOODS CARS CLASSIFIED AS EMPTY

BY

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OPINION

Hazard considerations relating to
unloaded ("empty") railway tank cars

The hazards from the failure or the rupture of loaded tanks on railcars are well-recognised and do not require full examination here. It is only necessary to state them as follows:

(1) Toxic materials. They may be in the form of liquefied gases, compressed gases or liquids with high vapour pressure. When containment is lost they offer a hazard to those who come within the influence of the gas/vapour dispersion. Many factore such as expired time, distance, atmospheric turbulence may reduce the danger. However those factors are not amenable to control. The situation is exacerbated by the fact that many loads carried on the railroads produce "heavy"vapours.
In addition consideration must be given to toxic liquids and both soluble and reactive solids that are toxic.

(2) Flammable materials. These may be gases liquefied under compression, compressed gases, refrigerated liquids and a range of liquids of varying vapour pressure. Under certain conditions loss of containment may lead to:
   (i) a pool or running fire
   (ii) an unconfined vapour cloud explosion (UVCE)
   (iii) a boiling liquid expanding vapour explosion (BLEVE) accompanied by a fire ball.

When the tank has been unloaded it is most unlikely that it will be entirely empty. In practice tanks are usually dedicated, and the only times when they are emptied and gas-freed is for cleaning, testing or repair. Thus after unloading the following situations obtain with referece to (1) and (2) above.

The toxic hazard . presented by the tank is reduced due to the vast reduction of toxic material available. However, if the tank is breached a hazard remains to those who are in close proximity to the tank at the time of the rupture. Clearly the risk is very much reduced.

Neither a UVCE nor a BLEVE is possible in that there is insufficient fuel to produce either of these events. The same is true for the pool and the running fires. The risk of these events is therefore removed.

However after unloading a new situation arises with tanks that held flammable gases, liquids and vapours. If such a tank is breached in either a collision or a derailment or failure of the tank or its fittings occurs air may enter the tank.

The flammable gas/vapour will mix with air and if there is a source of ignition present, combustion will occur in confinement. Sources of ignition are not usually wanting in the situation of a railroad incident. Thus the combustion will produce a rapid increase by up to 10 times the initial value. The ability of relief valves to handle this pressure is limited and the rupture already postulated will be of inadequate dimensions in the scenario depicted above.

Thus an explosion is produced and it may result in one or more of the following:

(i) a blast wave

(ii) break-up of the tank

(iii) rupture spreading from "stress-raisers" implanted by the first rupture

(iv) fittings may break loose and become missiles

(v) parts of the tank may become projectiles

Thus the net result of thos event involving an "empty" tank that originally carried flammable materials is the production of a greater or lesser blast wave with lesser or greater weight of missiles.

The energy of the explosion may be expressed in terms of a TNT equivalent and can be illustrated by reference to a propane tank. For every unit of volume of tank that originally carried 10 tonnes of propane, the TNT equivalent on ingress of air into the "empty" tank is 14kg. Thus if the tank originally contained 30 tonnes of propane then it is unloaded and later the "empty" tank full of propane gas is ruptured, thereexists the possibility of an explosion equivalent to up to about 40kg of TNT.
The effct of such an explosion may in turn be expressed in terms of the distance to which 50% breakage of glass windows occurs. The strength of glass is not precisely known; at best it can be expressed as a statistical value. Two values of scaled distance (S.D.) have been taken in the table below viz 40m $kg^{-\frac{1}{3}}$ and 80m $kg^{-\frac{1}{3}}$.

Size of tank (tonnes	TNT equivalent (kg)	Approx. distance for 50% window breakage (m) S.D. 40	S.D.80
10	14	95	190
20	28	120	245
30	42	140	280
40	56	155	305
60	84	175	350

In practice due to imperfect mixing and premature explosion these TNT equivalents are unlikely to be attained. Further the window glass is likely to be neither as weak or as strong as indicated although the quality of fixing is likely to influence the failure of the windows. The table gives an indication of the extent of light damage from variously sized tanks. Unfortunately such damage although light i.e. not structural, is universally recognised as very dangerous to persons who may suffer various injuries and effects from flying glass.
At lesser distances from the centre of explosion the effects will be more severe. Thus structural damage may be sustained by buildings that are immediately adjacent to the railroad. Of greater importance is the effect of such explosions upon persons

At short distances from a blast wave that is emanating from a vessel that is breaking up the precision with which effective distances can be given is less. The matter will therefore be expressed in terms of overpressure (i.e. pressure greater than ambient). There are two limits that have by implication been set so far.

(i) the overpressure at the exploding tank will be about 1000kPa

(ii) the overpressure required to break windows will be of the order of 2kPa

Within these limits the following are pertinent

(a) onset of damage to eardrums: 30kPa

(b) threshold of lung damage: 90kPa

Behind the blast front there is gas flow, an effect that is often referred to as windage. Windage imparts velocity to persons and objects thus causing them to become projectiles. Injury to persons results from this either by collision with a sharp object e.g. metal railings, structural steel or by sudden deceleration by encountering a solid mass e.g. the ground or a brick wall. Damage in such cases includes open wounds, broken skull and death.

From the foregoing it is clear that the situation with "empty" tanks amounts to trading one hazard for another. In some cases the hazard produced by a tank containing flammable materials is a localised fire. It is possible for the effects to be relatively small and localised. Accidents involving "empty" tanks can, as already described, lead to explosions. The effects of these will be more widespread than a localised fire. Thus the position arises where it is credible to think in terms of the hazard of an "empty" tank as being greater than that of a full one. This comment does not apply to situations where UVCE's and BLEVE's occur.

Thus it may be concluded that precautions taken to prevent disaster with full tanks of flammable materials are likely to be equally applicable to railcars with tanks that have been "emptied".

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